SECTION 6
SURFACE TREATMENTS

Asphalt surface treatment is a broad term embracing several types of asphalt and asphalt-aggregate applications, usually less than 25 millimeters (1 in.) thick and applied to any kind of road surface. The road surface may be a primed granular base, or an existing asphalt or Portland cement concrete (pcc) pavement. Surface treatments applied to an existing pavement surface are often called seal coats.

A single surface treatment, commonly called a chip seal, involves spraying asphalt emulsion and immediately spreading and rolling a thin aggregate cover. For multiple surface treatments, the process is repeated a second or even a third time with the aggregate size becoming smaller with each application. A sandwich seal is a relatively new technique in which a large aggregate is placed first, asphalt emulsion (normally polymer modified) is sprayed onto the aggregate, and immediately followed by an application of smaller aggregate on top that locks in the seal. A Cape seal is a single surface treatment followed by a slurry seal or micro-surfacing to fill in the voids between large aggregates.

A slurry seal is a mixture of dense graded aggregate, emulsified asphalt, fillers, additives and water. The slurry seal is applied as a thin surface treatment using a specially designed slurry seal machine. Microsurfacing is much like slurry seal, but through the addition of polymers and the use of specialized design techniques, micro-surfacing provides greater durability and can be placed thicker.

When properly constructed, asphalt surface treatments are economical, easy to place and long lasting. They all seal and add life to road surfaces but each type has one or more special purposes. A surface treatment is not a pavement in itself. It is primarily a cost-effective maintenance technique for prolonging the service life of a pavement. It resists traffic abrasion and provides waterproofing for the underlying structure. A surface treatment adds very little structural strength and, therefore, normally is not considered when determining the load carrying capability of a pavement.

While a surface treatment can provide an excellent skid resistant surface when used correctly, it is not a cure-all for all pavement problems. A clear understanding of the advantages and limitations of asphalt emulsion surface treatments is essential for best results. Traffic count, existing pavement condition, existing pavement structure, climatic conditions and available materials should all be taken into consideration when selecting and designing a surface treatment.

6.1 Uses of Surface Treatments

Surface treatments are primarily used to:

- Provide an economical, all-weather surface for light to medium traffic. When poly-

mer modified emulsions and high quality aggregates are used, surface treatments can be used for higher volume traffic applications.

- Provide a waterproof barrier that prevents the intrusion of moisture into underlying materials.
- Provide a skid-resistant surface. Pavements that have become slippery because of bleeding or wear and polishing of surface aggregates may be treated with sharp, hard aggregate to restore skid resistance. Sandwich seals are ideal for this purpose.
- Give new life to a dry, weathered surface. A weathered, raveled pavement can be restored to useful service by application of a single or multiple surface treatment.
- Provide temporary cover for a new base course. The surface treatment is appropriate cover for a new base course to be used through a winter or for planned stage construction. The surface treatment, especially a double seal coat, makes an excellent temporary surface until the final asphalt courses are placed.
- Salvage old pavements that have deteriorated because of aging and shrinkage of stress cracking. Although having little or no structural strength, a surface treatment can preserve the existing structural value by waterproofing and serve as an adequate stop-gap measure until a more permanent upgrading can be completed.
- Delineate shoulders from traffic lanes.

The need for a strong base or sound pavement under asphalt surface treatments cannot be overemphasized. The surface treatment is not designed to correct a pavement that is structurally deficient. Common base defects may include unstable materials, inadequate compaction, poor aggregates, lack of drainage and insufficient strength for the traffic.

6.2 Surface Treatment Materials

To produce high quality, durable, surface treatments, both the asphalt emulsion and the aggregate must meet established quality standards. Although other types of asphalt materials may be used for surface treatments, this manual only addresses the use of asphalt emulsions.

6.2.1 Asphalt Emulsion

Emulsions offer several advantages over other types of asphalt materials:

- They can be used with damp aggregate, which are actually preferred.
- They do not need highly elevated temperatures for proper application.
- They eliminate the fire hazard associated with cutback asphalts.
- They avoid the air quality problems associated with cutback asphalts.
- They provide quicker chip retention than cutback asphalts.
- They can be custom formulated for the existing conditions and available aggregates in most situations.

One of the keys to good performance lies in the selection of the correct type, grade, and application rate of emulsion. When the proper grade is selected, the asphalt emulsion for surface treatment will:

- Be fluid enough during application to spray properly and cover the surface uniformly
- Retain the proper consistency after application to wet the surface being treated and the applied aggregate
- Cure and develop adhesion to the aggregate and the surface quickly
- Hold the aggregate tightly to the road surface after rolling and curing, preventing loss of aggregate
- Not bleed or strip with changing weather conditions when applied at the proper rate

Table 6-1 Asphalt Emulsion Surface Treatments and Seal Coats shows the types of emulsified asphalt recommended for surface treatments and seals. Rapid setting asphalt emulsions are normally used for surface treatments, to react quickly with the aggregate and cure rapidly. High volume traffic roads may require a polymer modified rapid-setting emulsion.

Table 6-2 Suggested Distributor Spraying Temperatures for Various Grades of Asphalt Emulsions gives typical application temperature ranges for the various types and grades, including those not used for surface treatments but still which can require spray application. The use of these materials with relatively low temperatures is a significant energy-saving feature.

6.2.2 Aggregate

Any aggregate used on the surface is subjected to the abrasive action of traffic. If it is not hard enough to resist rapid wear, the pavement may become a skid hazard when wet. Most hard aggregates can be used successfully for surface treatments. Aggregates can be tested for abrasion resistance using the Los Angeles Abrasion Test, ASTM C 131 (AASHTO T 96). For surface treatment use, the abrasion wear should be not more than 45 percent. Crushed particles with rough surface texture and relatively low absorption will produce the best results. The aggregate selected must also meet the job requirements for size, shape, and cleanliness.

Size. The aggregate should be as close to one size as is economically practical, preferably in the range of 6 to 16 mm (1/4 to 5/8 in.) for single surface treatments. Larger sizes may be used in multiple treatments. If it is much larger than 16 mm (5/8 in.), it can cause objectionable tire noise. If much finer than 6 mm (1/4 in.), it is difficult to spread evenly. Also, finer aggregate lowers the allowable range for asphalt application rate.

Generally, the largest particle should be no more than twice the diameter of the smallest one. An allowance should be made for a slight amount of oversized and undersized particles. For single treatments, the top size is limited by the amount of emulsified asphalt that can be applied in one pass of the distributor without flowing off the surface.

Shape. The ideal shape for surface treatment aggregate is cubical. Flat or elongated particles are undesirable as they tend to become aligned on their flat sides and may be completely covered with asphalt when enough is used to hold the cubical particles in place (Figure 6.2-1). If all particles are flat, it takes so little asphalt to hold them that control becomes difficult. Rounded aggregate, such as uncrushed river gravel or pea gravel, will tend to roll over with traffic and dislodge, posing a difficult design solution.

Cleanliness. Clean aggregate is very important. If the particles are dusty or coated with clay or silt, the emulsion may not stick. The dust produces a film that prevents the asphalt from adhering to the aggregate surface. Care should be taken not to contaminate the aggregate stockpile.

Table 6-1 Asphalt Emulsion Surface Treatments and Seal Coats

Construction Type	Description and Uses	Typical Asphalt Emulsions	Construction Hints
Single Surface Treatment (Chip Seal)	Single most important low cost maintenance method. Produces an all-weather surface, renews weathered pavements, improves skid resistance, lane demarcation, and seals pavement.	CRS-2, RS-2	Spray-applied. Many types of textures available. Keys to success: Coordinate construction, use hard, clean aggregate and proper calibrate spray equipment.
Double Surface Treatment	Two applications of binder and aggregate. The second chip application uses a smaller sized stone than the first. Durable, provides some leveling, available in a number of textures.	CRS-2, RS-2, HFRS-2	See Chip Seal.
Triple Surface Treatment	Three applications of binder and 3 sizes of chips are applied. Provides up to a 20 mm (3/4”) thick, flexible pavement. Level as well as providing a seal, tough wearing surface.	CRS-2, RS- 2, HFRS-2	Spray-applied in three lifts.
Cape Seal	Combines a single chip seal with a slurry seal. Provides the rough, knobby surface of a chip seal to reduce hydroplaning yet has a tough sand matrix for durability. Test track data indicate better studded tire damage resistance than a chip seal. Friction values can be higher than conventional hot mix asphalt.	CQS-1h[1], CSS-1h, 1h, SS-1h, RS-2, CRS-2	Apply a single aggregate chip seal. After curing, QS-broom loose material and apply the slurry seal. Have the strike-off ride on the rock surface to form the matrix. Avoid excess slurry that can cover the desired knobby stone texture of the chips.
Sandwich Seal	Improves skid resistance, seals pavement. (usually polymer modified)	RS-2, CRS- 2, HFRS-2	Spread large aggregate, spray apply emulsion, and then cover with smaller aggregate to lock in larger aggregate. Clean aggregate required.
Sand Seal	Restores uniform cover. In city street work, improves street sweeping, traffic line visibility. Enriches dry, weathered pavement; reducing raveling.	CRS-1, CRS-2 RS-1, RS-2, MS-1, HFMS-1, HFRS-2	Spray-applied with with pneumatic roller. Avoid excess binder.
Slurry Seal	Used in airport and city street maintenance where loose aggregate cannot be tolerated. Seals, fills minor depressions, provides an easy-to-sweep surface. The liquid slurry is machine-applied with a sled-type box containing a rubber-edged strike-off blade.	DQS-1h, CSS-1h, QS-1h, SS-1h	Pretest the aggregate and emulsion mix to achieve desired workability, setting rate, and durability. Calibrate equipment prior to starting the project.

Table 6-1 Asphalt Emulsion Surface Treatments and Seal Coats (Continued)

Construction Type	Description and Uses	Typical Asphalt Emulsions	Construction Hints
Micro-surfacing[2]	High performance resurfacing used in highway, city street and airport maintenance where a durable, friction resistant resurfacing is required. Rapid roadway surface correction. Special rut filling application boxes and stringent design criteria permit filling wheel ruts up to 1.5 inches in depth in one pass.	CSS-1h (polymer modified)	A mix design should be required. Calibrate equipment prior to starting the project. Experienced personnel required for proper application.
Seal Coat	Applied to existing asphalt surfaces. Improves aesthetics, provides some crack sealing, and enriches weathered surfaces.	SS-1, SS-1h, CSS-1, CSS-1h	Spray or squeegee applied, with angular sand added. Allow complete cure before trafficking.
Fog Seal	A light spray application of binder applied to the surface of a chip seal, an open-graded mix, or a weathered hot mix surface. Provides some crack sealing, reduces raveling and enriches weathered surfaces.	SS-1, SS-1h, CSS-1, CSS-1h	Spray-applied with or without sand cover. Dilute the emulsion with water to help achieve coverage without adding excess binder.

NOTES:

1. The quick-set grades of emulsion (CQS-1h) have been developed for slurry seals. While not yet standardized, their use is rapidly Increasing, as the unique quick-setting property solves one of the concerns associated with the use of slurry seals.
2. The micro-surfacing grades of emulsion have been developed for high traffic and rut fill applications. While not yet standardized, their use is widespread.

Table 6-2 Suggested Distributor Spraying Temperatures for Various Grades of Asphalt Emulsions

Type and Grade of Asphalt Spraying Temperatures			Type and Grade of Asphalt Spraying Temperatures		
Asphalt Emulsion[1]	(°C)	(°F)	Asphalt Emulsion[1]	(°C)	(°F)
RS-1	20-60	70-140	HFMS-2s	20-70	70-160
RS-2	50-85	125-185	SS-1	20-70	70-160
HFRS-2	50-85	125-185	SS-1h	20-70	70-160
MS-1	20-70	70-160	CRS-1	50-85	125-185
MS-2	20-70	70-160	CRS-2	50-85	125-185
MS-2h	20-70	70-160	CMS-2	20-70	70-160
HFMS-1	20-70	70-160	CMS-2h	20-70	70-160
HFMS-2	20-70	70-160	CSS-1	20-70	70-160
HFMS-2h	20-70	70-160	CSS-1h	20-70	70-160

NOTES:

1. Temperatures also apply to polymer-modified versions of these emulsions.

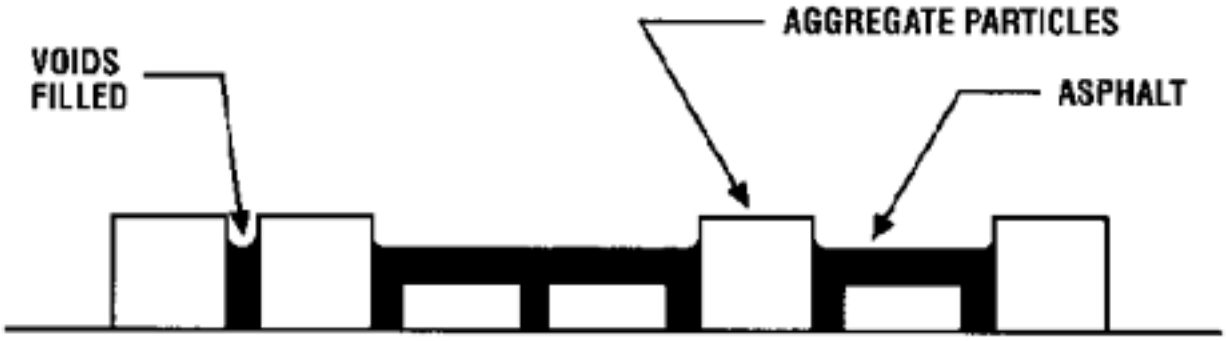

Figure 6-1 Flat Particles Are Covered When Enough Asphalt Is Used to Hold Cubical Particles

6.3 Types of Treatments and Seals

6.3.1 Single Surface Treatment

• Click here to see video. . . . . 

A single surface treatment, often called a “chip seal,” may be used for one of several reasons:

- As an interim measure pending application of an asphalt mixture
- To correct surface raveling and oxidation of old pavements
- To provide a waterproof, skid resistant surface over an existing pavement structure

A single treatment is especially suited for light to medium duty traffic and as a preventive or interim maintenance procedure. For higher traffic roads, a polymer modified emulsion used with high quality aggregate should be considered. Single treatments may also be used following crack sealing. The surface treatment is applied to resist the abrasive forces of the traffic.

Design of Single Surface Treatments. When a decision has been made to use a surface treatment, the next step is to find the proper rates of application for asphalt emulsion and aggregate. The objective is to produce a pavement surface one stone thick with enough asphalt to hold the aggregate in place, but not so much asphalt that it will bleed.

When a one-sized cover aggregate is dropped by a spreader on an asphalt film, the particles will be randomly oriented, After compaction under traffic, the particles will realign with about 20 percent voids between the particles. A desirable design is based upon 60 - 75 percent of the voids being filled with asphalt emulsion.

There are several theoretical procedures for determining the quantity of cover aggregate. These usually involve determining the average least dimension, the voids and loose unit weight of the cover aggregate. Mathematical calculations, coupled with laboratory testing, are usually employed in determining the required quantities of asphalt and aggregate. Rather than presenting a complex means of making these determinations, **Table 6-3 Quantities of Asphalt and Aggregate for Single Surface Treatments** is given as a general guideline. This table gives a range of asphalt and aggregate applications with respect to the specific size of aggregate being used. The suggested quantities of asphalt cover the average range of conditions that include primed granular bases and old pavement surfaces. The quantities and types of materials may be varied according to local conditions and experience. Traffic count and conditions should also be considered in surface treatment design. For a specific design, consult your local department of transportation or asphalt emulsion manufacturer for assistance.

6.3.2 Multiple Surface Treatments

A multiple treatment can produce a surface thickness of about 12 to 20 mm (1/2 - 3/4 in.). If properly designed and constructed, double surface treatments give about three times the service life of a single surface treatment for about 1 1/2 times the construction cost. Because the cover aggregate for the second layer is smaller, loss of particles from the surface treatment is greatly minimized.

In a double or triple surface treatment, the largest size of stone in the first course determines the surface layer thickness. The subsequent courses serve to fill the voids in the mat of the first cover aggregate. The extent to which these voids are filled determines the texture and riding quality of the multiple surface treatment.

A good, long-lasting pavement can be produced by increasing the thickness with additional surface treatments, either single or multiple, as traffic conditions demand.

Table 6-3 Quantities of Asphalt and Aggregate for Single Surface Treatments[1]

Nominal Size of Aggregate	Size No.	Quantity of Aggregate	Quantity of Asphalt kg/m^2 (lb/yd^2)	Type and Grade of Asphalt* l/m^2 (gal/yd^2)
19.0 to 9.5 mm (3/4 to 3/8 in.)	6	22-27 (40-50)	1.8-2.3 (0.40-0.50)	RS-2, CRS-2
12.5 to 4.75 mm (1/2 in. to No. 4)	7	14-16 (25-30)	1.4-2.0 (0.30-0.45)	RS-1, RS-2, CRS-1, CRS-2
9.5 to 2.36 mm (3/8 in. to No. 8)	8	11-14 (20-25)	0.9-1.6 (0.20-0.35)	RS-1, RS-2, CRS-1, CRS-2
4.75 to 1.18 mm (No. 4 to No. 16)	9	8-11 (15-20)	0.7-0.9 (0.15-0.20)	RS-1, MS-1, CRS-1, HFRS-2
Sand	AASHTO M-6	5-8 (10-15)	0.5-0.7 (0.10-0.15)	RS-1, MS-1, CRS-1, HFRS-2

NOTES:

1. Including polymer modified versions of these emulsions
   - These quantities of asphalt cover the average range of conditions that include primed granular bases and old pavement surfaces. The quantities and types of materials may be varied according to local conditions and experience.
   - The lower application rates of asphalt shown in the above table should be used for aggregate having gradations on the fine side of the specified limits. The higher application rates should be used for aggregate having gradations on the coarse side of the specified limits.
   - It is important to adjust the asphalt quantity for the surface condition of the road, increasing it if the road is absorbent, badly cracked, or coarse, and decreasing it if the road is flushed with asphalt. (See table below.)
   - It is important to adjust the asphalt quantity for traffic count and conditions. An increase in traffic will mean a decrease in asphalt content.

Table 6-4 Correction for Surface Condition

Pavement Texture	Correction[1]	
	L/M^2	(gal/yd^2)
Black, flushed asphalt	-0.04 to -0.27	(-0.01 to -0.06)
Smooth, non-porous	0.00	(0.00)
Absorbent		
• Slightly porous, oxidized	0.14	(0.03)
• Slightly pocked, porous, oxidized	0.27	(0.06)
• Badly pocked, porous, oxidized	0.40	(0.09)

NOTES:

1. This correction must be made from observations at the job site.

Design of Multiple Surface Treatments. There are several arbitrary design methods for multiple surface treatments. In the method described here, each course is designed as though it is a single surface treatment. For each succeeding course, the nominal top size of cover stone should be approximately onehalf the size of the previously placed aggregate. No allowance is made for wastage. After the first course, no correction is made for underlying surface texture.

As a general guideline, asphalt quantities for each course are added together. In a double seal, 40 percent of the total is applied for the first application and 60 percent for the second application. In a triple surface treatment, 30 percent of the total may be applied for the first application, 40 percent for the second and 30 percent for the third. (See **Table 6-5 Quantities of Asphalt and Aggregate for Double Surface Treatment** and **Table 6-6 Quantities of Asphalt and Aggregate for Triple Surface Treatment**.)

Table 6-5 Quantities of Asphalt and Aggregate for Double Surface Treatment

Application	Nominal Size of Aggregate	Size No.	Quantity of Aggregate kg/m^2 (lb/yd^2)	Quantity of Asphalt l/m^2 (gal/yd^2)
12.5 mm (1/2") Thick				
• 1st Application[1]	9.5 to 2.36 mm (3/8 in. to No. 8)	8	14-19 (25-35)	0.9-1.4 (0.20-0.30)
• 2nd Application	4.75 to 1.18 mm (No. 4 to No. 16)	9	5-8 (10-15)	1.4-1.8 (0.30-0.40)
15.9 mm (5/8") Thick				
• 1st Application[1]	12.5 to 4.75 mm (1/2 in. to No. 4)	7	16-22 (30-40)	1.4-1.8 (0.30-0.40)
• 2nd Application	4.75 to 1.18 mm (No. 4 to No. 16)	9	8-11 (15-20)	1.8-2.3 (0.40-0.50)
19.0 mm (3/4") Thick				
• 1st Application[1]	19.0 to 9.5 mm (3/4 to 3/8 in.)	6	22-27 (40-45)	1.6-2.3 (0.35-0.50)
• 2nd Application	9.5 to 2.36 mm (3/8 in. to No. 8)	8	11-14 (20-25)	2.3-2.7 (0.50-0.60)

NOTES:

1. If applied on untreated granular (stone) base, a penetrating prime is used in lieu of emulsion (See Chapter 8 Miscellaneous Applications).

Table 6-6 Quantities of Asphalt and Aggregate for Triple Surface Treatment

Application	Nominal Size of Aggregate	Size No.	Quantity of Aggregate kg/m^2 (lb/yd^2)	Quantity of Asphalt l/m^2 (gal/yd^2)
12.5 mm (1/2") Thick				
• 1st Application[1]	9.5 to 2.36 mm (3/8 in. to No. 8)	8	14-19 (25-35)	0.9-1.4 (0.20-0.30)
• 2nd Application	4.75 to 1.18 mm (No. 4 to No. 16)	9	5-8 (10-15)	1.1-1.6 (0.25-0.35)
• 3rd Application	4.75 mm to 150 µm (No. 4 to No. 100)	10	5-8 (10-15)	0.9-1.4 (0.20-0.30)
15.9 mm (5/8") Thick				
• 1st Application[1]	12.5 to 4.75 mm (1/2 in. to No. 4)	7	16-22 (30-40)	0.9-1.4 (0.20-0.30)
• 2nd Application	9.5 to 2.36 mm (3/8 in. to No. 8)	8	8-11 (15-20)	1.4-1.8 (0.30-0.40)
• 3rd Application	4.75 to 1.18 mm (No. 4 to No. 16)	9	5-8 (10-15)	0.9-1.4 (0.20-0.30)
19.0 mm (3/4") Thick				
• 1st Application[1]	19.0 to 9.5 mm (3/4 to 3/8 in.)	6	19-25 (35-45)	1.1-1.6 (0.25-0.35)
• 2nd Application	9.5 to 2.36 mm (3/8 in. to No. 8)	8	11-14 (20-30)	1.4-1.8 (0.30-0.40)
• 3rd Application	4.75 to 1.18 mm (No. 4 to No. 16)	9	5-8 (10-15)	1.1-1.6 (0.25-0.35)

NOTES:
1. If applied on untreated granular (stone) base, a penetrating prime is used in lieu of emulsion (See Chapter 8).

In multiple surface treatments, the first course of cover aggregate generally determines the thickness. Subsequent courses partially fill the upper voids in the previously placed courses.

6.3.3 Cape Seal

A Cape seal involves application of a slurry seal or micro-surfacing to a newly-constructed single surface treatment. The slurry or micro-surfacing application helps fill the voids between the chips. Cape seals provide a highly durable surface treatment. The slurry bonds the chips to prevent loss and the chips prevent undue traffic abrasion and erosion of the slurry. Cape seals are often used because of the color of the finished surface treatment.

6.3.3.1 Design of Cape Seal

For a successful Cape seal, it is important that the single surface treatment have a lower asphalt content than a conventional chip seal. The project should follow standard surface treatment design criteria and slurry seal or micro-surfacing specifications and methods (**Table 6-7 Quantities of Asphalt and Aggregate for Cape Seal**). The most critical element to avoid in a Cape seal is an excess of slurry that eliminates the desired knobby surface texture. A cure time of four to ten days should be allowed between placement of the surface treatment and subsequent slurry seal application. The

surface treatment should be broomed before application of the slurry seal or micro-surfacing to remove loose cover material or other foreign material that would prevent adherence.

Table 6-7 Quantities of Asphalt and Aggregate for Cape Seal

Application	Nominal Size of Aggregate	Size No.	Quality of Aggregate kg/m^2 (lb/yd^2)	Quantity of Asphalt l/m^2 (gal/yd^2)	Slurry Mixture (Type 1) kg/m^2 (lbs/yd^2)
12.5 mm (1/2") Thick	9.5 to 2.36 mm (3/8 in. to No. 8)	7	14-16 (25-30)	1.4-2.0 (0.30-0.45)	2.7-4.5 (6-10)
19.0 mm (3/4") Thick	19.0 to 9.5 mm (3/4 to 3/8 in.)	6	22-27 (40-50)	1.8-2.3 (0.40-0.50)	3.5-5.5 (8-12)

6.3.4 Sandwich Seal

A sandwich seal is constructed by spreading a large aggregate [15 - 20 mm (5/8 - 3/4 in.)], followed by the spraying of emulsion, and then an application of a smaller aggregate [5 - 13 mm (1/4 - 1/2 in]. The emulsion is normally a polymer modified version of RS-2, CRS-2, or HFRS-2, and typically is applied at a rate greater than for a single surface treatment but less than for a double. The smaller aggregate locks down the larger aggregate. The application of the large aggregate helps overcome existing problems of a bleeding surface. The aggregates must be clean and free of dust.

6.3.5 Sand Seal

A sand seal is a spray application of asphalt emulsion followed with a light covering of fine aggregate, such as clean sand or screenings. Although this is a rather simple operation, it can be useful in correcting a number of pavement flaws. Usually, RS-1, CRS-1, MS-1 or HFMS-1 emulsions are applied at a rate of about 0.70 to 1.25 liter/m^2 (0.15 - 0.28 gal/yd^2). This is followed by about 5.5 - 12 kg/m^2 (10 - 2 lb/yd^2) of sand or screenings cover. In some locations, sand seals are used when good sources of aggregates for chip seals are not available.

The sand seal is used primarily to:

- Enrich a dry, weathered or oxidized surface. The sand seal will help prevent loss of material from the old surface by traffic abrasion.
- Prevent the intrusion of moisture and air. When an existing pavement surface begins to crack, moisture and air may pass into the underlying pavement structure thereby reducing its load carrying ability. A sand seal can provide a barrier to prevent this intrusion.
- Develop a skid-resistant surface texture. By selecting a sharp, angular fine aggregate, a highly skid-resistant surface can be provided. Examples of angular aggregates are slag sand, or other manufactured sands. The sand may also be used to "soak up" spots of asphalt that have appeared because of an overly rich surface.

6.3.6 Slurry Seal

• Click here to see video. . . . . .

A slurry seal is a mixture of dense-graded aggregate, emulsified asphalt, fillers, additives and water. The mixture is applied as a surface treatment. Slurry seal can be both a preventive and a corrective maintenance technique. The treatment does not increase the structural strength of a pavement section. Any pavement that is structurally weak in localized areas should be repaired before applying the slurry seal. Ruts, humps, low pavement edges, crown deficiencies, or other surface irregularities that diminish riding quality should be corrected before placing the slurry seal.

Slurry seal is a very effective maintenance technique for the surfaces of older pavements. It will fill the surface cracks, stop raveling and loss of matrix, improve skid resistance and generally protect the pavement and reduce water and oxidation deterioration and thus extend overall pavement service life. Slurry seal has a number of advantages:

- Rapid application and quick return of traffic to the pavement
- No loose cover aggregate
- Excellent surface texture and friction resistance
- Ability to correct minor surface irregularities
- Minimum loss of curb height
- No need for manhole and other structure adjustment
- Excellent low cost treatment for urban streets

Slurry seal is applied in a thickness of 3 to 9 mm (1/8 - 3/8 in.). The machine used for mixing and application is a self-contained, continuous-flow mixing unit (**Figure 6-3 Flow Diagram of a Typical Slurry Seal Mixer**). It accurately delivers to the mixing chamber predetermined amounts of aggregate, mineral filler, additives, water, and asphalt emulsion.

Figure 6-2 Akzo Noble HD10 Slurry Seal Equipment

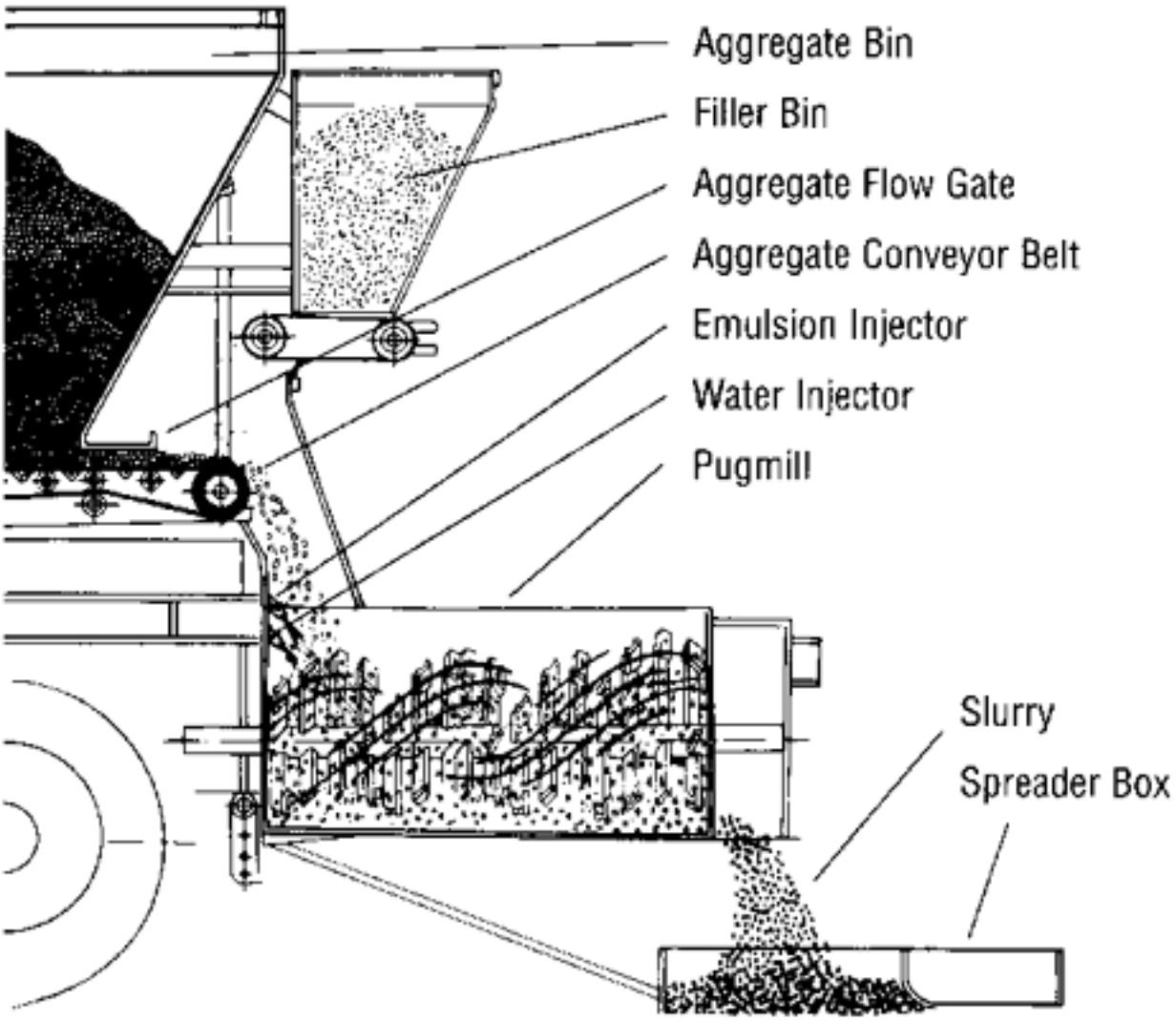

Figure 6-3 Flow Diagram of a Typical Slurry Seal Mixer

Table 6-8 Slurry Seal Aggregate Gradings[1]

Gradation Type	I	II	III
General Usage	Crack filling & fine seal	General seal, medium textured surfaces	Produces highly textured surfaces
Sieve Size	Percent Passing	Percent Passing	Percent Passing
9.5 mm (3/8in.)	100	100	100
4.75 mm (No. 4)	100	90-100	70-90
2.36 mm (No. 8)	90-100	65-90	45-70
1.18 mm (No. 16)	65-90	45-70	28-50
600 µm (No. 30)	40-65	30-50	19-34
300 µm (No. 50)	25-42	18-30	12-25
150 µm (No. 100)	15-30	10-21	7-18
75 µm (No. 200)	10-20	5-15	5-15
Residual Asphalt Content, % weight of dry aggregate	10-16	7.5-13.5	6.5-12
Application Rate, kg/m^2 (lb/yd^2), based onweight of dry aggregate	3.6-5.4 (8-12)	5.4-9.1 (12-20)	8.2-13.6 (18-30)

NOTES:
1. Recommended by the International Slurry Surfacing Association.

The slurry machine has a continuous flow mixing unit with either a single or double shafted pugmill. Mixed slurry seal is discharged from the pugmill into a spreader box. The spreader box is equipped with flexible squeegees and has an adjustable width. Spreader boxes may be equipped with hydraulically power augers to uniformly distribute material across the spreader box width. Augured boxes are especially beneficial when quick-set (QS) emulsion is used or when the pavement contains grades greater than 8%. One type of slurry mixer unit is shown in **Figure 6-3 Flow Diagram of a Typical Slurry Seal Mixer**.

Slurry seal aggregate must be clean, angular, durable, well graded, and uniform. A 100% crushed material should be used when it is available. An individual aggregate or a blend of aggregates to be used in a slurry mix should meet these limits:

- Sand equivalent value, ASTM D 2419 (AASHTO T 176) = 45 minimum.
- Soundness, ASTM C88 (AASHTO T 104) = 15% maximum using Na_2SO_4 or 25% maximum using $MgSO_4$
- Los Angeles abrasion loss, ASTM C 131 (AASHTO T 96) Grading C or D = 35% maximum.

Three aggregate gradations are used for slurry seals (**Table 6-8 Slurry Seal Aggregate Gradings**). Type I gradation is a thin sealing course that provides maximum crack penetration and good sealing properties. Type I slurry seal also makes an excellent pretreatment for a hot mix asphalt overlay or chip seal. It performs well in low traffic density areas where the primary objective is sealing, such as parking lots, light aircraft airfields, or shoulders.

Type II is the most widely used slurry seal gradation. Type II slurry seal protects the underlying pavement from oxidation and water damage and it improves surface friction. In addition, Type II slurry seals can correct severe raveling. It is used for moderate

traffic density pavements. The Type III gradation is used to attain heavy application rates and high surface friction values. Type III slurry seal is used for heavy traffic density roadways.

Asphalt emulsion used in the slurry seal may be SS-1, CSS-1, SS-1h, QS-1h, CSS-1h or CQS-1h. The cement mixing test is waived for CQS-1h and QS-1h emulsions. The correct emulsion for any given slurry seal aggregate can be verified by a mix design.

Relatively small amounts of liquid or powdered additives can be added to the slurry seal mixture. The materials may be used to improve mix characteristics, setting characteristics or other post cure properties. These additives include Portland cement, lime and aluminum sulfate in addition to some organic chemicals. The performance of any given additive must be demonstrated in the mix design. Water used in the slurry must be potable and compatible with the mix.

Performing a mix design in the laboratory prior to the application is important for selecting the proper materials and a compatible mixture. The **International Slurry Surfacing Association's** Design Technical Bulletins contain further information on mix design. Correct blending should produce slurry with a creamy homogeneous texture that will flow smoothly in a rolling wave ahead of the strike-off squeegee. There should be no emulsion runoff.

It is essential to calibrate each slurry seal machine with the exact materials to be used on the slurry project. The calibration should reflect the materials proportions designated by the mix design. Reports of previous calibrations on these same materials may be accepted if they were performed within the current calendar year. Trial applications should be used as a final check of slurry consistency and workability. It is important to repair all areas of base failure before applying the slurry seal. Seal cracks in the pavement surface with an acceptable crack sealant. Finally, the surface must be cleaned of all loose materials, oil spots, vegetation and other foreign matter. Any standard cleaning method will be acceptable. If water is used, cracks must be dry before applying the slurry seal.

A tack coat is not generally required prior to slurry seal application unless the surface is extremely dry and raveled or is concrete or brick. If required, the tack coat should consist of one part of emulsified asphalt and three parts of water. The distributor shall be capable of applying the dilution evenly at a rate of 0.25 to 0.45 l/m^2 (0.05 to 0.10 gals/yd^2). The tack coat must cure before applying the slurry seal. When required by local conditions, the surface shall be lightly dampened by fogging with water ahead of the spreader box. The rate of application of the fog spray can be adjusted during the day to suit current conditions. Spray bars are located on the slurry seal machine for water fogging. Excessive fogging that creates puddles in front of the spreader box should be avoided.

During application of the slurry seal, there should be no lumping, balling, or unmixed aggregate visible in the spreader box. Enough material should be carried in all parts of the spreader box so that complete coverage is attained. Overloading of the spreader must be avoided. Streaks, such as those caused by oversized aggregate, should be repaired at once with a hand squeegee.

Care must be taken to prevent excessive buildup of slurry seal at longitudinal and transverse joint lines. A maximum of 150 mm (6 in.) of overlap is permitted on longitudinal joints. Transverse joints must be smooth enough to permit quiet transition of vehicles.

Hand squeegees and hand drags are used to improve joints, correct minor imperfections and place the slurry in areas inaccessible to the machine. The area to be handworked should first be lightly dampened with water. The slurry seal can then be deposited and immediately worked onto the surface with hand squeegees. Care should be exercised not to leave an unsightly appearance in handworked areas. Hand application of slurry seal should be limited and should only be conducted in areas impossible to reach by machine.

Rolling is seldom required for a slurry seal. Use of a pneumatic-tired roller can assist in airport and parking lot projects where existing traffic does not sufficiently compact the slurry after application. A common 9 - 11 tonne (10 - 12 ton) nine-wheel pneumatic-tired roller with 350 - 425 kPa (50 - 60 psi) tire pressure is adequate, and two passes of the roller are generally sufficient. It is important to roll when the slurry seal is set enough to support the roller without having material pick up on the tires. Steelwheeled rollers are not appropriate for slurry seal. These rollers tend to bridge on the high spots of the pavement and fail to compact in the low areas. They will also mark the surface and could crush the larger aggregate.

Slurry should not be placed when the temperature of the pavement or air is below 10°C (50°F) and falling, but may be applied when both pavement and air temperature are above 7°C (45°F) and rising. Slurry seal should not be applied when there is the possibility that the finished product will freeze within 24 hours after application. Slurry should not be applied during excessively foggy conditions or in periods of rain.

Additional information on slurry seal can be obtained from:

International Slurry Surfacing Association (ISSA)
1200 19th Street NW
Suite 300
Washington, D.C. 20036

6.3.7 Micro-Surfacing

• Click here to see video . . . . . 

Like slurry seal, micro-surfacing is a mixture of well graded aggregate, asphalt emulsion, fillers, additive and water, but through the addition of polymers and the use of specialized design techniques, micro-surfacing can achieve multiple stone depths.

As a surface treatment, micro-surfacing imparts protection to the underlying pavement and provides renewed surface friction values. Special emulsifiers in micro-surfacing emulsions contribute quick setting characteristics. Formulations are required under average conditions to allow the return of straight running traffic to the surface in one

hour. Minor reprofiling can be achieved with multiple applications. Special equipment permits the filling of wheel ruts up to 40 mm (1 1/2 in.) deep in one pass. Micro-surfacing features and benefits include:

- Quick set, quick traffic feature.
- Chemical break permits night time application.
- Suitable for use on high traffic volume, limited access highways.
- Single pass application rates of 11 - 16 kg/m^2 (20 - 30 lbs/yd^2), yielding micro-surfacing depths from 9 - 16 mm (3/8 - 5/8 in.) in depth.
- Scratch course followed by a finishing course provides minor reprofiling and a new riding surface.
- Rut filling followed by a finishing course provides proper water drainage and reduces the possibility of vehicle hydroplaning.

Figure 6-4 Akzo Noble CRM500 Continuous Laydown Micro-Surfacing Unit

Micro-surfacing is mixed and placed by specialized, compartmented, self-powered trucks. Highly accurate proportioning assures proper ratios of the continuous feed for each component. The mixing chamber is a double shafted, multi-bladed pugmill that quickly combines and thoroughly mixes the materials. The semi-fluid micro-surfacing mixture falls into an augured screed box and is deposited on the pavement across a full lane width as the truck moves forward on the roadway.

Continuous laydown micro-surfacing trucks (Figure 6.3-3) are supplied with aggregate and asphalt emulsion by nurse trucks and produce resurfacing with a minimum of transverse joints. This type of equipment is capable of producing up to 450 tonnes (500 tons) of micro-surfacing per day. Truck mounted units can also be used for micro-surfacing if proper feed accuracy and rapid pug mill mixing can be achieved. These units return to the stockpile for refilling after depositing a full load of aggregate. Micro-surfacing rut boxes are designed to deposit material directly into pavement wheel ruts. Multiple rut filling passes can correct depressions in excess of 50 mm (2 in.) in depth. This technique permits the correction of hydroplaning hazards without milling the existing surface.

Aggregates used for micro-surfacing are manufactured, 100% crushed stone such as granite, slag, limestone, chat, or other high quality aggregate. An individual aggregate or blend of aggregates must meet these standards for use in micro-surfacing:

- Sand equivalent value, ASTM D 2419 (AASHTO T 176) = 60 minimum.
- Soundness, ASTM C 88 (AASHTO T 104) = 15% maximum using Na_2SO_4 or 25% maximum using $MgSO_4$
- Los Angeles abrasion loss, ASTM C 131 (AASHTO T 96) Grading C or D = 30% maximum.

The two generally accepted aggregate gradations for micro-surfacing are listed in Table 6.3-6. Type II aggregate is used for general resurfacing of streets and medium volume roadways. Type III aggregate is used for heavy traffic resurfacing, minor reprofiling, rut filling and areas where high friction values are desirable.

CSS-1h-p emulsions are the most widely used for micro-surfacing system. These materials are used to trigger the proper breaking characteristic in the mix. Organic surfactants are often used as mixing aid additives. As with slurry seal, the water used in micro-surfacing must be potable and compatible with the mix.

A micro-surfacing mix design must be performed in the laboratory prior to application. Correct blending of materials should produce a semi-fluid mixture of thoroughly coated material. There should be no emulsion runoff. Setting of the material and the appearance of clear water should take place within 30 minutes.

Table 6-9 Micro-Surfacing Aggregate Gradings[1]

Gradation Type	II	III
General Usage	General resurfacing, sealing and renewal of surface friction	High volume roadway resurfacing, rut filling. Produces high-friction surfaces
Sieve Size	Percent Passing	Percent Passing
9.5 mm (3/8 in.)	100	100
4.75 mm (No. 4)	90-100	70-90
2.36 mm (No. 8)	65-90	45-70
1.18 mm (No. 16)	45-70	28-50
600 µm (No. 30)	30-50	19-34
300 µm (No. 50)	18-30	12-25
150 µm (No. 100)	10-21	7-18
75 µm (No. 200)	5-15	5-15
Residual Asphalt Content, % weight of dry aggregate	5.5-9.5	5.5-9.5
Application Rate, kg/m2 (lb/yd2), based on weight of dry aggregate	5.4-9.1 (12-20)	8.2-13.6 (18-30)

NOTES:
1. Recommended by the International Slurry Surfacing Association.

It is important to calibrate the micro-surfacing machine with the exact materials to be used on the project. The calibration should reflect the materials proportions designated by the mix design. Reports of previous calibrations on these same materials may be accepted given that they were performed within the current calendar year. Trial applications may be used as a final check of slurry consistency and workability. Night application of micro-surfacing requires special formulations. It is advisable to demonstrate the formulation's ability to cure in night conditions with trial passes before the project is to begin.

It is important to repair all areas of base failure before application of micro-surfacing. Seal cracks in the pavement surface with an acceptable crack sealant. Finally, the surface must be cleaned of all loose material, oil spots, vegetation, and other foreign matter. Any standard cleaning method will be acceptable. If water is used, cracks must be dry before applying the micro-surfacing.

Micro-surfacing is self-tacking. A tack coat is not required unless the surface to be treated is extremely dry and raveled or is concrete or brick. If required, the tack coat should consist of one part of emulsified asphalt and three parts of water. The distributor shall be capable of applying the dilution evenly at a rate of 0.23 to 0.45 l/m^2 (0.0 5 to 0. 10 gal/yd^2). The tack coat must cure before the micro-surfacing application.

When required by local conditions, lightly dampen the surface by fogging with water ahead of the spreader box. The rate of application of the fog spray can be adjusted during the day based on the current conditions. Spray bars are located on the micro-surfacing machine for water fogging. Enough material should be carried in all parts of the spreader box at all times to attain complete coverage. Overloading of the spreader must be avoided. Streaks, such as those caused by oversized aggregate, should be repaired at once with a hand squeegee.

Care must be taken to prevent excessive buildup of micro-surfacing at longitudinal and transverse joint lines. Longitudinal joints should be minimized and placed on the center lane lines, when possible. A maximum of 150 mm (6 in.) of overlap is permitted on longitudinal joints. Transverse joints must be smooth enough to permit quiet transition of vehicles.

Hand squeegees and hand drags are used to improve joints, correct minor imperfections and place the micro-surfacing areas inaccessible to the machine. The areas to be handworked should first be lightly dampened with water. The micro-surfacing can then be deposited and immediately worked onto the surface with hand squeegees. Care should be exercised not to leave an unsightly appearance to the handworked areas. Hand application of micro-surfacing should be limited.

Rolling is rarely required for micro-surfacing as vehicular traffic normally provides adequate compaction. When rolling is required by special conditions, a 9 to 11 tonne (10-12 ton) ninewheel pneumatic tired roller with 350 - 425 kPa (50 - 60 psi) tire pressure is adequate for use and two passes of the roller is generally sufficient. It is important to roll when the micro-surfacing is set enough to support the roller without having material pick up on the tires. Steel wheeled rolling is not recommended. These rollers tend to bridge on the high spots of the pavement and fail to compact in the low areas. They also can mark the surface and could crush larger aggregate.

In general, micro-surfacing should cure for 24 hours between multiple passes. This curing permits water to evaporate and strength to build in the underlying passes. Also, traffic consolidation in filled ruts and other thick areas will build maximum compacted strength.

Micro-surfacing normally should not be placed when the temperature of the pavement or air is below 10°C (50°F) and falling, but may be applied when both pavement and air temperatures are above 7°C (45°F) and rising. Application should not be attempted when there is a possibility that the finished product will freeze within 24 hours after application. Micro-surfacing should not be applied during rain. Additional information on micro-surfacing can be obtained from:

International Slurry Surfacing Association
1200 19th Street NW
Suite 300
Washington, D.C. 20036

6.3.8 Seal Coat

A seal coat is an application of asphalt emulsion to an existing paved asphalt surface. The asphalt emulsion may be sprayed or squeegeed on the existing pavement surface. This type of maintenance treatment is primarily employed to improve the aesthetics of an existing pavement by providing a uniform black color to the surface and to obscure differences in the pavement surface texture. In addition, the sealer will provide an impervious membrane that will slow the rate of weathering of the asphalt in the underlying pavement.

The types of emulsion used for seal coats are SS-1, SS-1h, CSS-1, and CSS-1h. Coarse, angular sand is generally added to the emulsion for increased skid resistance. It is added at a rate of 0.5 - 0.8 kg per liter (4 - 7 lb. per gallon) of emulsion. About 0.5 l/m^2 (0.1 gal/yd^2) should be applied in a single application. If an additional application is desired, it should be applied at a right angle to the first on. The seal coat must be allowed to completely cure before traffic is applied to prevent pickup by vehicle tires.

6.3.9 Fog Seal

• Click here to see video. . . . . 

A fog seal is a light application of diluted slow-setting emulsion sprayed on an existing asphalt surface. The emulsion can be diluted up to one part emulsion to five parts water (1:5) but in most cases, a one to one dilution is used. The asphalt emulsions normally used are SS-1, SS-1h, CSS-1 and CSS-1h. A fog seal can be a valuable maintenance aid. However, it is not a substitute for asphalt surface treatments such as sand or chip seals. It is used to renew old asphalt surfaces that have become dry and brittle with age and to seal very small cracks and surface voids. It also coats aggregate particles at the surface. This corrective action can prolong pavement life and possibly delay the need for major maintenance or rehabilitation, particularly if applied in a timely manner.

The total quantity of fog seal is normally from 0.45 - 0.70 l/m^2 (0.10 - 0.15 gal/yd^2) of diluted material. The surface condition or texture, dryness and degree of cracking of the pavement determine the quantity required. The seal coat should be allowed to completely cure before traffic is applied to prevent pickup by vehicle tires.

6.4 Surface Treatment Construction

The equipment used for surface treatment construction has a major impact on the quality of the finished product. It should be kept in proper adjustment and good operating condition using routine maintenance and frequent inspections for excessive wear, breakdown and calibration.

NOTE

Over-application of the fog seal must be avoided as this will result in asphalt pickup by vehicles and possibly a slippery surface. When excess emulsion is applied, a light application of fine sand on the affected area may correct the problem.

6.4.1 The Asphalt Distributor

The asphalt distributor is the most important piece of equipment used in surface treatment construction (**Figure 6-5 Asphalt Distributor**). It is used to uniformly apply the asphalt emulsion over the surface at the specified rate. The distributor consists of either a truck-mounted or trailer-mounted insulated tank with controls to set the asphalt application rate. At the rear of the tank is a spray bar equipped with nozzles through

which the asphalt is forced under pressure onto the pavement surface. Spray bars can cover widths of 3 to 9 m (10 to 30 ft.) in a single pass, depending on the pump capacity. A hand spray is included to apply the emulsion to areas that cannot be reached with the spray bar.

Figure 6-5 Asphalt Distributor

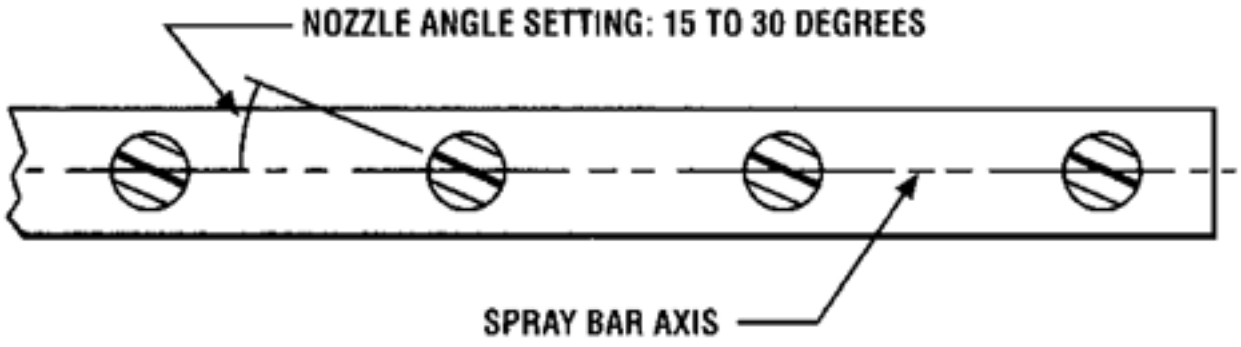

Figure 6-6 Proper Nozzle Angle Setting

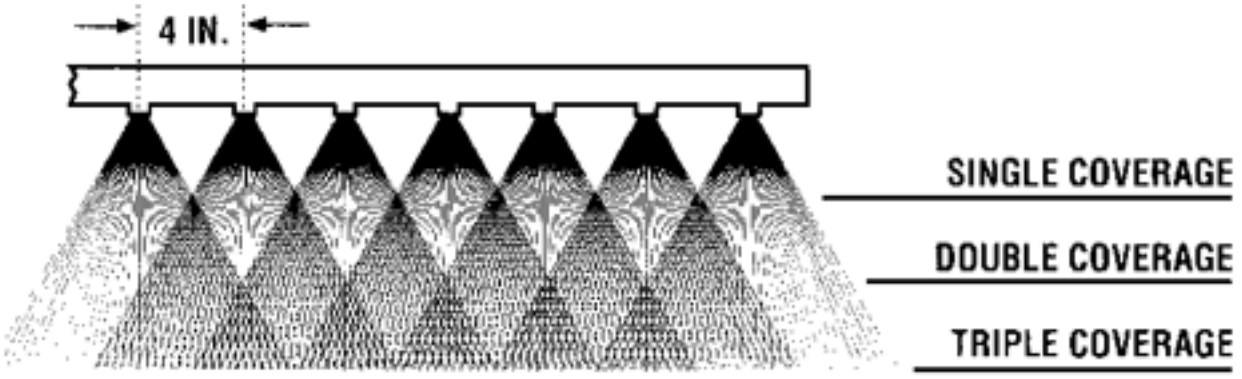

Figure 6-7 Spray Bar Height Must Be Set Exactly for Proper Coverage

The distributor tank typically has a capacity of 3,000 to 20,800 liters (800 - 5,500 gal.). The tank has a circulating system that includes the spray bar. Pressure generated when a noncirculating or not bypassed spray bar is shut off can cause the emulsion to break and plug the unit with asphalt. The tank is also equipped with one or more heaters used to bring the emulsified asphalt to the proper spraying temperature. Extreme care is required when using these heaters. Premature breaking of the emulsion may occur if heating temperatures are too high. If the heaters are to be used, the emulsion should be circulating in the tank while heat is applied and excessive temperatures must not be allowed.

Two extremely important adjustments are the spray nozzle angle setting and spray bar height. The angle of the nozzle openings must be adjusted so that the spray fans will not interfere with each other. The recommended angle, measured from the spray bar axis, is from 15 to 30 degrees (**Figure 6-6 Proper Nozzle Angle Setting**). To ensure a uniform spread, the spray bar must be set and maintained at the proper height above the pavement surface. If it is set too high, wind distortion of the spray fans may occur. The best results usually are achieved with an exact double coverage, but triple coverage can sometimes be used with spray bars with 100 mm (4 in.) nozzle spacing. **Figure 6-7 Spray Bar Height Must Be Set Exactly for Proper Coverage** illustrates the heights of the spray bar necessary to achieve these coverages.

Three controls are standard equipment on most distributors. One is a valve system that governs the flow of asphalt material. Another is a pump tachometer or pressure gauge that registers pump output. The third is a bitumeter with an odometer that indicates the number of meters (feet) per minute and the total distance traveled.

Despite the precise controls on a distributor, it is always advisable to check the rate of application in the field. This can be done with a shallow metal tray exactly one square meter (one sq. yd.) in area. If a tray is not available, a sheet of heavy paper or cardboard can also be used. The tray is weighed and placed on the surface to be sprayed. Immediately after the distributor has passed, the tray is removed and weighed again. The difference between the two is the mass (weight) of the asphalt emulsion. The asphalt emulsion application rate can then be determined by this equation:

$$R=w/D$$

where

R = asphalt emulsion application rate, liters/m^2 (gal/yd^2)

w = mass (weight) of asphalt emulsion on tray, kg/m^2 (lb/yd^2)

D = density of asphalt emulsion at 15.6°C (60°F), kg/liter (lbs/gal)

NOTE

The rate at the spraying temperature can be determined by dividing R by the M temperature-volume correction factor (see **Table B-1 Temperature-Volume Corrections for Asphalt Emulsion**).

6.4.2 Aggregate Spreader

The aggregate spreader is second only to the asphalt distributor in the order of importance of surface treatment equipment. It applies a uniform aggregate cover at the specified rate. Spreaders range from the simple vane type attached to a truck tail gate to the highly efficient self-propelled type.

Tailgate spreaders are usually one of two types. One is a steel plate to which is attached a series of vanes to provide coverage across the lane (**Figure 6-8 Tailgate Vane Spreader**). Another is a truck-mounted hopper with a feed roller activated by small wheels driven by the truck wheels (**Figure 6-9 Hopper-Type Tailgate Spreader**). In each case, the truck backs up to spread the stone. This prevents the freshly applied asphalt from being picked up by the truck tires.

Mechanical aggregate spreaders contain hoppers and a built-in distribution system to ensure a uniform spread of the cover aggregate across the entire lane width. Mechanical spreaders are either truck-attached (**Figure 6-10 Truck-Attached Mechanical Spreader**) or self-propelled (**Figure 6-11 Self-Propelled Mechanical Spreader**). In both types, the aggregate is dumped from a truck into a receiving hopper for spreading. The truck-attached spreader typically contains an auger and a roughened spread roll in the hopper that ensures a positive, uniform feed of material. The selfpropelled unit has a similar feed mechanism.

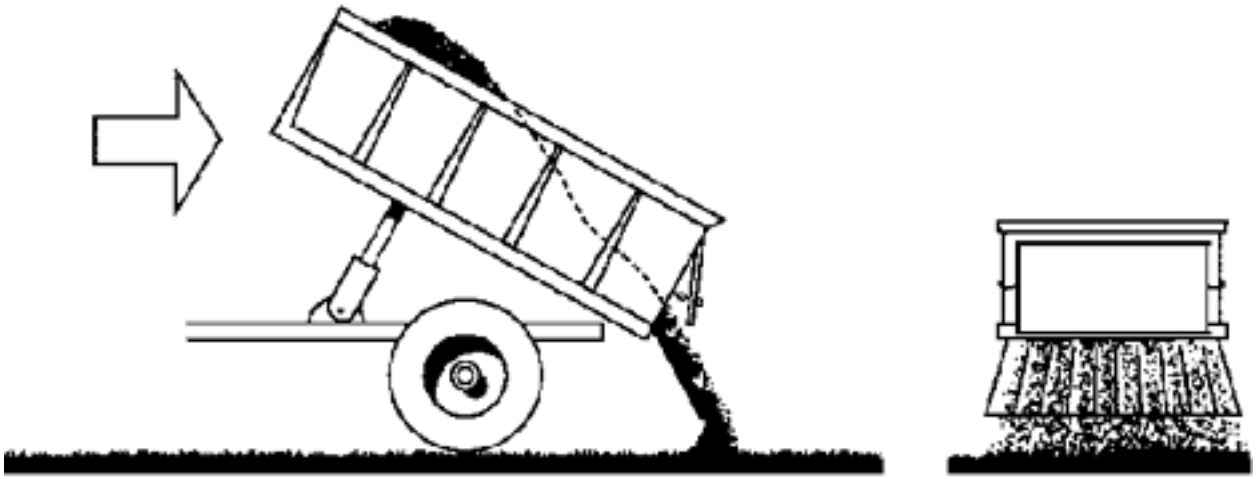

Figure 6-8 Tailgate Vane Spreader

Figure 6-9 Hopper-Type Tailgate Spreader

One difference is that the self-propelled spreader contains a scalping screen over the aggregate receiving hopper. Another is that there can be a sloped screen that allows

the larger particles to drop into the asphalt film first with the finer particles falling afterwards through the screen. This system ensures that the larger particles are sufficiently embedded in the asphalt to hold them in place. The self-propelled unit has the advantage of being able to closely follow behind the asphalt distributor, with minimum stopping to change aggregate trucks.

Mechanical self-propelled aggregate spreaders should be calibrated to apply the design quantity of cover stone for any given project. The required equipment can be very simple and may consist only of several sheets of canvas, each exactly one square meter (square yard), and a scale. By making several runs at different speeds and gate openings over the sheets of canvas and carefully weighing the aggregate deposited on them, the gate opening and spreader speed required to apply the cover stone at the specified rate per square meter (square yard) can be quickly determined.

Figure 6-10 Truck-Attached Mechanical Spreader

Figure 6-11 Self-Propelled Mechanical Spreader

Figure 6-12 Pneumatic-Tired Roller

6.4.3 Rollers

Rolling presses the aggregate down into the asphalt binder, promoting better adhesion. Unless the cover aggregate is properly embedded in the asphalt film, there is a good possibility that some may be lost through traffic abrasion. For single surface treatments, pneumatic-tired rollers produce best results (**Figure 6-12 Pneumatic-Tired Roller**). They force the aggregate firmly into the asphalt binder without crushing the particles. The tires press into small depressions to better seat the particles. Steel-wheeled rollers tend to bridge over such depressions and may fracture the aggregate. If the roller speed is too high, the roller may dislodge the aggregate.

Figure 6-13 Power Sweeper

6.4.4 Power Broom

Unless the surface to be covered is completely clean, the asphalt may not adhere to the pavement. Therefore, it is necessary to clean the whole surface before spraying the asphalt emulsion (**Figure 6-13 Power Sweeper**). Power sweepers or brooms are also used to remove loose particles after the treatment is completed. On a new surface treatment, it is advisable to lightly broom during cooler periods of the day to prevent chip roll over.

6.4.5 Trucks

Enough trucks must be available to ensure that the surface treatment operation can proceed without interruption. Frequent stops and starts may cause variations in asphalt spray distribution, rate of aggregate covoer, or both, and result in a non-uniform surface. By sgtaggering backing patterns, trucks can also be used to roll the finished surface treatment to help embed the aggregate before the regular rolling is begun. Truck speed and turning should be carefully controlled to prevent dislodging chips.

Figure 6-14 Surface Treatment Operation

6.4.6 Sequence of Operations

The sequence of operations is basically the same for all types of surface treatment construction:

1. Patch potholes and repair damaged areas in the existing pavement. Allow enough time for curing of the patch mix. If a coarse patch mix is used, fog sealing may be advisable.
2. Clean the surface with a power sweeper or rotary broom or by another approved method.
3. Spray the asphalt emulsion binder at the specified rate and proper temperature.
4. Spread the cover aggregate at the specified rate immediately behind the asphalt spray application (emulsion still brown in color) to achieve maximum possible chip wetting.
5. Roll the cover aggregate adequately to properly seat particles in asphalt film.

Figure 6.4-10 shows a proper surface treatment operation. If a double or triple surface treatment is required, steps **3** through **5** will be repeated once or twice.

All equipment must be in proper working order before construction begins. An adequate supply of aggregate should be available on the job site, or scheduled for delivery at proper intervals with adequate haul trucks to permit continuous spreading opera-

tions. The required quantity of asphalt emulsion should also be stored or scheduled to arrive promptly at the job site to prevent delays in construction. An adequate traffic control plan should be developed.

6.4.7 Precautions

Most problems with surface treatments are caused by failure to adhere to common-sense construction practices. Even when the highest quality aggregates and asphalt emulsions are used, inferior surface treatments may result unless strict guidelines are followed. An attempt at short cuts or construction during poor weather will probably result in poor performance and increased maintenance.

Surface treatment operations should not be carried out during periods of cold or wet weather. Conventional guidelines recommend air temperatures of at least 10°C (50°F) in the shade and rising. Generally, the temperature of the road surface should be above 27°C (80°F) before an asphalt spray application can be applied. The asphalt emulsion may not break or cure properly at lower temperatures and therefore, the asphalt will not satisfactorily retain the cover aggregate.

Surface treatments should not be constructed in the rain, when rain is threatening, or on wet pavement. The water may cause a loss of the partly cured emulsion from the cover aggregate. New technology has produced emulsions, usually polymer modified, which can be used at cooler temperatures or at night. Your local asphalt emulsion supplier should be contacted for specific recommendations.

A simple rule of thumb can be cited when rapid-setting emulsions are used for surface treatments. The emulsion selected should break just after the first roller pass has been made. This assumes that the roller is following closely behind the aggregate spreader and that the spreader, in turn, is trailing immediately behind the asphalt distributor. This sequence should result in good wetting of the cover aggregate by the asphalt emulsion and the development of satisfactory adhesion between the emulsion and cover aggregate. Also, good cover aggregate retention should occur when the surface treatment is opened to traffic.

6.4.8 Checking Application Rate

Checks on the rate of application of asphalt emulsion should be made after each run with the distributor. This can be simply done using this formula:

S.I. Metric	**U.S. Customary**
R = TM / WL	R = 9TM / WL

where:

R = Rate of application, liter/m^2 (gal/yd^2)

T = Total liters (gallons) spread from the distributor at the spraying temperature, that is, gauge stick reading before spread minus gauge stick reading after spread

W = Width of spread, m (ft)

L = Length of spread, m (ft)

M = Multiplier for correcting asphalt volume to basis of 15.6°C (60°F) (from Table B-1 in Appendix B Miscellaneous Tables).

6.5 Surface Treatment Safeguards

A few simple safeguards will greatly increase the chance of success when a surface treatment is used. These “common-sense” items apply to most other types of construction as well.

- The design is done properly and all materials used meet the job specifications to assure the job will give the desired performance.
- The existing pavement structure is strong enough to support expected traffic loads before the surface treatment is applied.
- All construction equipment is inspected to insure proper operation. Calibration of gauges, meters and aggregate spreader and inspection of spray nozzles are completed.
- The asphalt emulsion and aggregate are compatible. The proper emulsion (cationic or anionic) is chosen and the aggregate is free from dust and slightly moist for the best results.
- The emulsion application rate and amount of cover aggregate is carefully designed.
- The proper type and weight of rollers are selected.
- Proper construction techniques are followed.
- There is proper traffic control.
- The work is performed only in weather conditions suitable for the type of emulsion selected.
- Improvements in technology have led to new emulsions that can be formulated specifically for cooler weather.

Adhering to the simple safeguards will help prevent problems. Three of the most common problems and their causes are:

6.5.1 Streaking

This is the non-uniform application of the asphalt emulsion on the road surface (**Figure 6-15 Longitudinal Streaking**).

Longitudinal streaking shows up as alternating lean and heavy narrow bands of asphalt running parallel to the centerline of the pavement. Streaking not only leaves an unsightly appearance, it can also greatly reduce service life through the loss of cover aggregate. A single centerline streak may be caused by too little or too much emulsified asphalt at the joint between two applications.

Causes of longitudinal streaking include:

- An improper spray bar height causing incorrect overlap of the spray fans.
- Spray bar changing height as the distributor load decreases with asphalt discharge.
- Nozzles on spray bar are not set at correct angle, not all set at same angle, the wrong size, different in size, plugged or restricted, or have imperfections.
- Incorrect asphalt emulsion pump speed or pressure
- Asphalt emulsion too cold.
- Asphalt emulsion viscosity too high for existing conditions and equipment.

6.5.2 Bleeding (Flushing)

This is a surface that is too rich in asphalt (**Figure 6-16 Bleeding Asphalt**). Bleeding can cause a slick, hazardous condition, especially during wet weather. The most common causes of bleeding of a surface treatment are an improper application rate of asphalt emulsion, improper aggregate application, or water vapor pressure from the base or subgrade causing stripping that results in the asphalt coming to the surface. Bleeding may also be a result of pre-existing bleeding of the old surface. This may be addressed using a sandwich seal.

Figure 6-15 Longitudinal Streaking

Figure 6-16 Bleeding Asphalt

Figure 6-17 Loss of Cover Aggregate

This is the whipping-off of aggregate under traffic from a surface treated pavement that leaves the asphalt uncovered (**Figure 6-17 Loss of Cover Aggregate**). This condition can be dangerous because loose aggregate thrown by the tires of a moving vehicle can cause windshield damage. Also, the aggregate-free asphalt, now resembling bleeding, can become a skid hazard.

Several things can cause the loss of cover aggregate:

- The aggregate may not adhere to the applied emulsion if not spread at the proper time.
- Dry, dusty aggregate may cause premature breaking of the asphalt emulsion that leaves insufficient asphalt to hold the aggregate under traffic.
- If not rolled immediately after placing, the aggregate may not become seated firmly enough to hold under traffic.
- Other causes include: not enough asphalt emulsion; too little aggregate embedment; weather too cool before, during and after application; high humidity; the surface being treated too wet or dusty; fast traffic too soon on the new surface treatment; a surface that absorbs part of the asphalt leaving too little to hold the aggregate; and rain washing away the emulsion.